I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 11054

Product Market Competition and Employer Provided Training in Germany

John S. Heywood
Uwe Jirjahn
Annika Pfister

SEPTEMBER 2017

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 11054

Product Market Competition and Employer Provided Training in Germany

John S. Heywood
University of Wisconsin-Milwaukee

Uwe Jirjahn
University of Trier and IZA

Annika Pfister
University of Trier

SEPTEMBER 2017

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Product Market Competition and Employer Provided Training in Germany

Using German establishment data, this paper examines the relationship between product market competition and the extent of employer provided training. We demonstrate that high product market competition is associated with increased training except when the competition is so severe as to threaten liquidation to a firm. We take this as evidence of an inverted U-shaped relationship. We also make clear that while this relationship is very evident for the service sector it is largely missing for manufacturing where we confirm earlier results of no relationship.

JEL Classification: J24, L00, M53

Keywords: competition, employer provided training, manufacturing, services

Corresponding author:
John S. Heywood
Department of Economics
University of Wisconsin-Milwaukee
P.O. Box 413
Milwaukee, WI 53201
USA

E-mail: heywood@uwm.edu

1. Introduction

This paper adds evidence to the fledgling literature on product market competition as a determinant of employer provided training. As we will make clear, both theory and evidence remain mixed on whether product market competition acts to spur or deter employer provided training. We add to the debate by arguing for a more nuanced view in two dimensions. First, competition should be anticipated to spur training investments only when it is not so severe as to increase the likelihood of firm insolvency. As the likelihood of insolvency increases, any expected returns on training diminish. Second, competition may be anticipated to increase training largely in those industries in which workers' human capital plays a more important role in the competitiveness of firms. We argue that service industries may be disproportionately such industries. In manufacturing other steps may more cheaply increase competitiveness such as cost-reducing process innovations. Competitive advantages and, hence, the firms' average responses to competition likely differ between these two broad sectors.

Using recent German data, we present evidence confirming this more nuanced view. We show that establishments in more competitive product markets engage in greater training but not when that competition is a source of potential insolvency and liquidation. Thus, we confirm an inverted U-shaped relationship between competition and training in which the least training is done in dominant firms and by firms in those markets so competitive that insolvency and liquidation is feared. We also demonstrate that an influence of competition is far more evident (perhaps only evident) in service industries. This seems crucial given that studies finding no influence of competition often limit themselves to only manufacturing.

In the next section we review past literature with an eye toward showing the lack of consensus in both theory and empirical evidence. We also build the case that the two dimensions

we view as important, the non-linear influence of competition and broad sectoral differences in the influence of competition, deserve special consideration. The third section describes our data sources and the critical measures that we use. The fourth section presents the evidence, while the final section concludes.

2. Background Discussion

2.1 Past Research and the Need to Reexamine

Workplace training creates important human capital that immediately fits the needs of firms (Booth and Snower 1996). It reduces production cost (Dearden *et al*. 2006, Moretti 2004, Zwick 2006), increases wages and profitability (Jones et al. 2012, Konings and Vanormelingen 2015, Lynch 1994) and generates positive externalities (Blundell et al. 1999). Given these potential benefits, an accelerating literature explores if competitive product markets generate more or less workplace training. The theory and evidence are decidedly mixed and it is undoubtedly fair to claim that no consensus exists.

The lack of consensus on the role of product market competition can be contrasted with the dominant view that increased labor market competition decreases employer provided training. Becker (1964) argued that employers will simply not invest in general training in competitive labor markets due to a poaching problem. The evidence that firms do provide general training (Katz and Ziderman 1990, Krueger 1993, Stevens 1994, Acemoglu and Pischke 1998, Booth and Bryan 2005) has been explained by labor market frictions and wage compression (associated with less than competitive markets) that makes skills *de facto* firm-specific (Acemoglu and Pischke 1998, 1999). At an extreme, all industry-specific skills move from fully general to fully firm-specific as the labor market moves from perfectly competitive to monopsonistic (Manning 2003). In this view,

increased labor market competition reduces employers' overall incentives to invest in training. Indeed, Brunello and Gambarotto (2007) confirm empirically that employer-provided training is lower in more competitive labor markets.

In contrast, the theoretical relationship between product market competition and employer provided training appears highly dependent upon assumptions (Wolter and Ryan 2011: pp. 533-534). Bilankos et al. (2017) argue that more competition reduces the potential rents from training and so should be associated with lower training intensity. Their model builds from Vives (2008) who showed that when firm outputs are strategic substitutes, expenditures on cost reducing innovation (such as training) fall as the number of firms increase.

Gersbach and Schmutzler (2012) model oligopolistic competition with two firms producing a differentiated good and also suggest that increased competition decreases training. Training is assumed to be industry-specific: it increases productivity not only with the current employer but also with other firms operating in the same industry. Strong competition (a high degree of substitutability of products) aggravates the poaching problem. It increases the probability of a worker leaving her current employer and, thus, reduces the employer's incentives to invest in the worker's human capital. In this way, the role of product market competition mimics some of the logic from the discussion on labor market competition.

Bassanini and Brunello (2011) predict a positive effect of increased product market competition on employer provided training. They consider firm-specific training and assume monopolistic competition. The authors model an increase in product market competition as a reduction in entry barriers. This deregulation has two opposite effects. On the one hand, it entails a negative rent effect. The deregulation decreases profits per unit of output associated with training and, thus, reduces employers' incentives to invest in the human capital of their employees. On the

other hand, the deregulation involves a positive business stealing effect. A larger number of firms results in a higher price elasticity of demand increasing the positive impact of training on a firm's individual demand and output so that firms have a higher incentives to finance training. In Bassanini and Brunello's model the latter effect dominates the first one.

Lai and Ng (2014) present a signaling model that implies an ambiguous influence of competition on training. In the model, both firms and workers can invest in the human capital of the latter. While a firm provides training to increase imperfectly transferable human capital, workers make firm-specific investments by learning the nuts and bolts of the firm. Workers' specific investments are higher if they expect a longer employment horizon with the current firm. There are bad firms with a low probability of survival and good firms with a high probability of survival. The survival probability is private knowledge of the firm's management. In a separating equilibrium, good firms signal their higher survival probability through a larger amount of training to induce higher specific investments of their workers. Product market competition has two opposite effects. On the one hand, it lowers the probability of survival for both types of firms reducing expected returns to training and, hence, decreasing the incentive to provide training. On the other hand, it lowers the survival probability of good firms less than that of bad firms. This strengthens good firms' incentives to use training as a signal to differentiate themselves from bad ones. The overall impact of competition on training depends on the relative strength of the two effects.

Thus, theory presents a series of opposing effects of product market competition on employers' incentives to invest in the human capital of their employees. Predictions include a positive, a negative or no association between competition and training. In the end, empirical research will determine which effect dominates.

Yet, empirical evidence also remains inconclusive. Two studies show no association between product market competition and training, one using Dutch worker-manufacturing firm data on firm sponsored training (Picchio and van Ours 2011), the other using German manufacturing data (Görlitz and Stiebale 2011). By contrast, using Canadian data, Xu and Lin (2011) and Lai and Ng (2014) find a positive link between competition and training. Similarly, Bassanini *et al*. (2007) and Bassanini and Brunello (2011) demonstrate a positive relationship between product market deregulation and training in Europe. Studies for the U.S. provide mixed results. While Li (2009) finds a negative link between import competition and company training, Autor (2001) shows that temporary help firms facing more competition provide more computer training. Using British data, Bilankos et al. (2017) find that establishments which dominate their product market actually do more training. They show little difference between moderately competitive and fully competitive market structures. Finally, for Switzerland, Muehlemann and Wolter (2007) obtain a negative link between product market competition and training.

This quick review shows that, just as with the theory, the evidence suggests no association, a positive association and a negative association between product market competition and training. This gives rise to the question of how the very mixed findings can be reconciled. In what follows we argue that the mixed evidence may reflect a nonlinear influence of product market competition on employer provided training. Moreover, the influence of product market competition may differ between broad industries.

2.2 A Nonlinear Relationship between Product Market Competition and Training

Our first point of leverage is that the influence of product market competition on training could be nonlinear. Up to some point, product market competition may increase the incentives of firms to

invest in the human capital of their employees. Firms provide training in order to increase their competitiveness and, hence, to escape and survive competition. However, beyond that point higher competitive pressure decreases the firms' incentive to provide training. The chance to succeed becomes so low so that in the end they are discouraged from large investments in their employees' human capital. This may be specifically the case if managers anticipate that competitive pressure puts the firm at risk of insolvency and liquidation. Such pressure shortens the time horizon over which returns on training can be recouped. The probability of persistence is simply too low to justify extensive training investments.

This point of leverage builds from the literature on competition and innovation. Aghion et al. (2005) argue that product market competition has heterogeneous effects on innovation activities. It encourages neck-and-neck firms to innovate in order to escape competition, but discourages laggard firms from innovating (a Schumpeterian effect).[1] The authors' theoretical model implies an inverted U-shaped relationship between product market competition and innovation as a composition effect at the industry level. At initially low levels of competition, firms are neck to neck so that the escape competition effect is the dominating response to a rise of competition. At high levels of competition laggard firms compete with technological leaders so that on average the Schumpeterian effect dominates.

Indeed studies for the UK (Aghion et al. 2005), the Netherlands (Polder and Veldhuizen 2012) and the US (Levin et al. 1985) have confirmed an inverted U-shaped relationship between product market competition and innovation at the industry level. Moreover, there is evidence that neck-and-neck firms respond with increased and laggard firms with decreased innovation activities to heightened competition (Aghion et al. 2009, Ding et al. 2016). However, a growing number of studies also show that the inverted U-shaped relationship is not simply a composition effect at the

industry level (resulting within industries from heterogeneous responses of firms to competition), but rather even holds at the individual firm level. Studies for Finland (Kilponen and Santavirta 2007), France (Askenazy et al. 2013), Sweden (Tingvall and Karpaty 2011, Tingvall and Poldahl 2006), Switzerland (Peneder and Woerter 2014), the UK (Aghion et al. 2009), and the US (Bos et al. 2013) find that rising competitive pressure increases innovation activities of an individual firm at low levels of competition, but ultimately decreases the firm's innovation activities at high levels of competition.

While the exact logic behind the various findings varies modestly, the basic notion remains that the extent of competitive pressure combined with the competitive strength or weakness of a firm plays a crucial role in the firm's incentive to undertake investments. We expect that this should also hold for investments in workers' human capital. Our data provide unique firm-specific information on product market competition allowing us to differentiate the circumstances of high competitive pressure. We know when the management of firm feels acute competitive pressure, but does not feel that it puts the firm at risk. We also know when the management feels acute competitive pressure and does feel that the pressure puts the firm at risk of insolvency and liquidation. We suggest that, just as in the literature on investing in innovation, this could prove a critical difference for investing in training. Even if competition spurs increased investment in training, it will not do so for those firms at risk of insolvency and liquidation. Failure to isolate this difference may result in general estimates that find little or no relationship between competition and training.

2.3 The Moderating Role of Industry

The second point of leverage that interests us is the apparent difference in the training results by sector. Görlitz and Stiebale (2011) examine German firms in the manufacturing sector. They find no relationship between product market competition and the extent of training. Picchio and van Ours (2011) obtain a similar result for manufacturing firms in the Netherlands. This can be contrasted with Tignvall and Karpaty (2011) who examine the service sector in Sweden. They show an inverse U-shaped relationship of competition with both innovation and training. Tignvall and Karpaty view their examination of training as largely secondary but supportive of their primary interest in innovation. The contribution they claim is confirming the inverse U-shaped relationship in the service sector that others found earlier studying innovation and competition in manufacturing.

Yet, what interests us is the contrast in the training results between the service sector and the manufacturing sector. The contrasting findings of the three studies raise the possibility that the influence of product market competition on training systematically differs between broad industries. Competitive advantages and, hence, firms' average responses to competition may differ between the service and the manufacturing sector. Previous studies on competition and training did not test for such systematic differences.

It seems likely that competition may increase training largely in those industries in which workers' human capital plays a more important role in the competitiveness of firms. Service industries may be disproportionately such industries. This view is supported by the management literature (Batt 2002, 2008, Hipp and Grupp 2005, Skaggs and Youndt 2004). While manufacturing firms produce physical goods, the output of service firms, such as consultancy or maintenance, is to a large degree intangible and, thus, is often less standardized. Much of what customers purchase

is a process. This process involves high levels of contact and interaction between customers and employees as many services are supplied and consumed simultaneously. The provision of a service usually relies to a large extent on humans. Employees who come into direct contact with customers are 'part of the product' (Batt 2008). They are directly responsible for service quality, customer satisfaction and customer retention. Quality of services involves reliability, responsiveness to the individual customer's demands and empathy for the customer. Thus, employees' human capital is of particular importance. In order to meet heterogeneous preferences of customers, employees need not only a clear understanding of specific service features, but also customer-specific knowledge of particular individuals and market segments. This suggests that training can immediately increase competitive advantage in the service sector. It contributes the employees' capability to deal with varying customer needs, to understand idiosyncratic situations and to identify suitable services that fulfill the specific needs.

While the boundaries between the service and the manufacturing sector may have blurred, there still appear to be substantial differences. Manufacturing firms typically produce a tangible output that can be to a larger extent standardized. As production and consumption of the output are separated, employees remain part of the production process, not part of the product. Moreover, production relies to a larger extent less on physical infrastructure and machines. These characteristics suggest that manufacturing firms may take other steps than investing in training to increase competitiveness. They may respond to increased product market competition by investing in technologies, machines and equipment that improve quality or save labor. While this can indirectly influence their training decisions, the basic point remains that manufacturing firms respond initially and primarily with technological investments and that the influence of competition on training should be less strong than for service firms.

In what follows, we are the first to examine economy wide data in Germany to determine the relationship between the competitive pressure that an establishment faces and its intensity of training. We will contrast the evidence from the service and manufacturing sectors and will test for the inverted U-shaped relationship. We are careful to make clear both our measure of competitive pressure and the exact measure of training. In the next section we briefly discuss employer provided training in Germany and introduce important controls that we anticipate will influence training. That section also describes our data and the advantages of our chosen measures.

3. Data and Variables

3.1 The Data Set

We draw data from the IAB Establishment Panel of the Institute for Employment Research. The IAB Establishment Panel is a representative sample of establishments from all sectors in the German economy. The IAB is the research institute of the German Federal Employment Agency and they contract with Infratest Sozialforschung, a professional survey and opinion research institute, to conduct the interviews.

The data are collected on the basis of a questionnaire and follow-up personal interviews with the owner or top manager of the establishment. Each year since 1993 (1996), the IAB Establishment Panel has surveyed several thousand establishments in Western (Eastern) Germany. Basic information on the establishment and a core set of questions are asked annually. Additional topics are introduced in specific waves. Details on the survey methodology can be found in Fischer et al. (2009).

In the year 2009, there has been a reclassification of industrial sectors. Thus, our empirical analysis is based on waves 2009–2015. Most importantly, these waves contain a new firm-specific measure of product market competition. For the analysis, we focus on privately owned commercial

establishments with at least five employees. We exclude establishments that have changed their broad sectoral affiliation within the period we examine.

2.2 Employer Provided Further Training

In Germany, employers can provide two types of training, namely apprenticeship training and further training. The distinctive feature of the German system of apprenticeship training is its dual structure (Harhoff and Kane 1997, Winkelmann 1996). Apprentices typically attend publicly-funded vocational part-time schools 1–2 days a week in addition to working and learning at the workplace. Employers bear the cost of within-firm training voluntarily. The apprenticeship training ends after 2–3.5 years. Detailed curricula are developed in cooperation with state institutions, employer organizations and trade unions. Regionally organized chambers of commerce and chambers of crafts coordinate and administer the programs.

In contrast to apprenticeship training, employer provided further training is characterized by a very low degree of regulation by the state (Allaart et al. 2009). There is no legal framework regulating the content, financing or structure of such training. Employer provided further training is an investment in workers' human capital that aims at a better understanding of, or coping with, current job tasks (Brussig and Leber 2006). Usually further training takes place after an apprenticeship training and/or an initial period of work experience (Gerlach and Jirjahn 2001). It can be organized in form of courses and seminars or it can be integrated in the process of work itself. Further training can take place internally or externally. Employer provided further training plays an important role in Germany. In the year 2013, employers in Germany invested about 33.5 billion Euro in further training (Seyda and Werner 2014).

Our dependent variable is the share of the establishment's employees who received employer provided further training during the first half of the respective year. The questionnaire asks if the establishment provided further training by releasing employees from work and/or by financing training entirely or in part. Those employers that provided further training were asked to report the number of employees who received training. This number is divided by the number of all employees in the establishment. The dependent variable takes value zero if the establishment did not provide further training. On average the establishments in our sample provided further training to just over a quarter of their employees. Table 1 shows the definitions and descriptive statistics of the variables used in our analysis.

2.3 Product Market Competition

The waves of the IAB Establishment Panel used for our analysis provide a new self-reported measure of the competitive pressure establishments face at their product markets. The measure asks managers to identify one of five levels of competitive pressure: no, minor, medium, major without threat of liquidation, or major with threat of liquidation. This question does not provide a quantitative measure such as a concentration index, but instead allows the managers to identify the extent of competition. To do this the managers are implicitly identifying the product and geographic markets in which the establishment competes.

Self-reported competition measures have been used by Blanchflower and Machin (1996), Bloom et al. (2010) and Lai and Ng (2014) among others. These self-reported measures have a series of advantages over traditional industry-level measures such as the Herfindahl index or the import penetration ratio. First, while industry-level measures of competition implicitly assume that firms within the same industry face the same level of competition, the self-reported firm-specific

measure takes into account that firms within the same industry may face different degrees of competitive pressure.[2] Importantly, our unique measure enables us to directly identify the critical case when the competition is associated with the risk of liquidation.

Second, firms may have businesses across multiple industries and regions that are characterized by different degrees of competition. The self-reported measure of product market competition allows interviewees to include relevant competitors even when they are outside the standard industry or geographic boundaries of the official index. Thus, international competitors or those from a different detailed industry code could be included by the manager even as they would be excluded by industry-level official statistics.

Third, while industry-level measures of product market competition are often only available for the manufacturing sector, self-reported measures do not face this restriction. They provide information on competitive pressure for all private sector industries. This allows us to move beyond the manufacturing sample of Görlitz and Stiebale (2011).

2.4 Control Variables

The dataset provides a rich set of control variables. A series of variables capture the structure of the workforce. To the extent employer provided further training is complementary to the employees' initial qualification, the shares of skilled workers and university graduates should have a positive influence on further training so that further training widens the skill gap between educated and less educated employees (Arulampalam et al. 2004, Gerlach and Jirjahn 2001, Lynch and Black 1998).[3] We also include the share of apprentices. This variable indicates the general propensity of an employer to train workers. Moreover, some employer may offer additional courses and seminars already to their apprentices. Furthermore, the use of temporary agency

workers and the shares of women and part-timers are controlled for. The influence of these variables is ambiguous. On the one hand, they may be seen as indicating a low expected tenure of the workforce resulting in less training. On the other hand, they may reflect a high share of peripheral workers protecting a core group of workers who receive more training.

Dummy variables for job vacancies for unskilled and for skilled and highly skilled workers are also included. Moreover, the data contain an additional dummy for difficulties in filling vacancies for skilled and highly skilled workers. The latter variable indicates labor market shortages. If labor market shortages make it difficult to fill vacancies for skilled and highly skilled employees, the employer has an increased incentive to train current workers who temporarily take on tasks of the unfilled positions.

Technological change is captured by the amount of investments in physical capital per employee. Moreover, an ordered variable for the vintage of production technology and dummy variables for investments in machines and for investments in computer systems and ICT are included in the regressions. Technological change can be viewed as being skill-biased (Acemoglu 2002, Autor et al. 2003). New technologies substitute for unskilled workers in routine tasks while they complement skilled workers in performing complex non-routine tasks. One way to cope with the increased demand for skills is to train workers (Gashi et al. 2008, 2010, Gerlach and Jirjahn 2001, Lynch and Black 1998). Moreover, technological change contributes to the obsolescence of initial vocational training (Blechinger and Pfeiffer 2000). This requires further training to keep workers' skills up to date. Finally, establishments investing in new technologies may provide further training to increase workers' willingness to cooperate with the implementation of labor-saving technologies. To the extent workers are trained in more than one job, they are less likely to

be dismissed when technological change is introduced (Carmichael and MacLeod 1993). This reduces workers' resistance to change.

Variables for the presence of a works council and the coverage by a collective bargaining agreement are included to control for the dual system of worker representation in Germany. Works councils provide a highly developed mechanism for establishment-level codetermination. They are expressly provided for by the Works Constitution Act, but their creation depends on the initiative of the establishment's employees. Thus, works councils are not present in eligible establishments (Jirjahn and Smith 2006). Works councils can be seen as a collective voice institution ensuring that managers take employees' interest into account (Freeman and Lazear 1995, Smith 2006). They promote internal labor market and reduce personnel turnover. Reduced mobility of the employees, in turn, increases employers' incentives to invest in the human capital of their employees (Gerlach and Jirjahn 2001). Collective bargaining agreements are usually negotiated between unions and employers' associations on a broad industrial level. The agreements regulate wage rates and general aspects of the employment contract. Unions can also include further training in the bargaining agenda in order to improve workers' employment opportunities (Hardes 1991). Employers are covered by collective agreements if they are members of an employers' associations.

We also include a dummy for the use of alternative forms of employee involvement such as staff spokesmen, round tables or worker committees. Alternative forms of employee involvement should be positively associated with employer provided training (Gerlach and Jirjahn 2001, Lynch and Black 1998). On the one hand, alternative forms of employee involvement may take on a role similar to that of a works council. On the other hand, increased employee

involvement may reflect skill-biased organizational change (Bresnahan et al. 2002, Caroli and Van Reenen 2001).

Furthermore, we control for multi-establishment status. Being part of a multi-establishment firm should be positively associated with training. If training involves fixed costs, the fixed costs can be spread over a number of establishments (Lynch and Black 1998). A similar reasoning may also apply to establishment size. However, previous research for Germany has provided mixed results. While empirical studies clearly show a positive association between establishment size and training incidence, results on the relationship between size and the share of employees trained range from negative (Allaart et al. 2009) to positive (Brussig and Leber 2006).

A series of variables capture general establishment characteristics. Ownership is controlled for by variables for a dominant foreign owner and dispersed ownership. The reference group consists of establishments with a dominant domestic owner. Establishment age is taken into account by a dummy for the foundation of the establishment after the year 1990. Finally, industry, region and time dummies are included.

4. Empirical Analysis

4.1 Initial Estimates

In the initial specifications we include establishments throughout the economy and explore the importance of distinguishing between intense competitive pressure that is productive and that which destructive. The first specification in Table 2 includes a single dummy variable for high competitive pressure regardless of whether it threatens liquidation or not. The estimate suggests that the intensity of competition plays no role. The coefficient on high competitive pressure is

associated with a .09 increase in the share trained but the standard error is very large and the measure is not statistically different from zero.

This can be contrasted with the identical specification that simply divides the two types of high competitive pressure. This specification is shown in the second column and tells a different story. First, the coefficient on high pressure with a threat of liquidation becomes negative suggesting that training in such establishments is even less common than in those facing no competitive pressure. Yet, this coefficient is not statistically different from zero. Second, the coefficient on high pressure but without a threat of liquidation appears to double and indicates that such establishments train 18 percent more of their workforce than firms facing no competitive pressure. Critically, this measure is easily statistically significant. Thus, in the ordinary least squares estimates, the fact that competition is associated with greater training becomes evident only when recognizing that the competition must not be threatening to the establishment's on-going survival. This fits with our notion that firms on the brink of failure will not make substantial investments in training.

The importance of separating the high pressure variables is not unique to the OLS specification. In column 3, we re-estimate a Tobit specification using the same independent variables. This specification recognizes that some establishments do no training and that the decision to train at all should be incorporated into the estimation. The coefficient is no longer simply the change in trained share. Instead, it should be interpreted as the combination of the change in the share for those above zero, weighted by the probability of being above zero and the change in the probability of being above zero, weighted by the expected training share of those above zero. Despite this difference in interpretation, the broad results are very similar. The coefficient on high pressure with a threat remains negative and that for high pressure without a

threat is still positive and highly significant. Moreover, the coefficient on medium competitive pressure takes a positive but intermediate coefficient. The probability of training and its extent increase with competitive pressure but returns to at least the same level as with no competitive pressure when it is so intense that liquidation is threatened.

The fourth column shows a fractional logit specification. Papke and Wooldridge (1996) point out that in comparison with a log-odds estimation, the fractional logit model does not need to use *ad hoc* transformations to handle data at the extreme values of zero and one. Yet, it keeps the advantage of the log-odds model, the transformed variable ranges from minus infinity to plus infinity and so ensures that the predictions of the dependent variable remain within the zero to one bound which is not guaranteed with OLS. In this specification the basic result of inverted U remains. Training in establishments with a threat of liquidation is at least as small as in those establishments with no pressure. Training in establishments with high pressure but no threat of liquidation is significantly greater than in those same establishments with no pressure. Indeed, the average marginal effects are essentially identical to those from the OLS. Thus, in three related regression models the importance of the inverted U remains showing the importance of separating high pressure without threat of liquidation from high pressure that threatens to close the establishment.

Many of the controls take significant coefficients of the expected sign. A modern production technology, investments in information technology and machines, and employee involvement are positively associated with the share of workers receiving employer provided further training. This fits the hypothesis that skill-biased technological and organizational change leads to higher investment in training. The shares of apprentices, skilled workers and university graduates are also positive determinants of employer provided further training. These results

conforms to the notion that training widens the skill gap between educated and less educated employees. Vacancies for skilled workers and university graduates and also difficulties in filling these vacancies emerge as positive determinants. This suggests that employers train current employees who temporarily take on tasks of the unfilled positions with high skill requirements. By contrast, vacancies for unskilled workers are negatively associated with training. Industrial relations also play the anticipated role. The variables for works council incidence and collective bargaining coverage are positively linked to training. Furthermore, being part of a multi-establishment firm, foreign ownership, foundation after 1990, use of temporary agency work and the share of women are positive determinants while the share of part-time workers is a negative determinant. Establishment size appears to have a nonlinear influence.

4.2 Random Effects and Fixed Effects Estimates

We now examine the robustness of our inference by exploiting the panel nature of the data. We present both random and fixed effect estimates of the influence of competition on training. In the random effect estimates, the assumption is that the establishment effects are drawn from its own distribution. Thus, an advantage of the random effect model is that the total residual variance can be partitioned into two components: a between establishment variance and a within establishment variance. The first column of Table 3 shows the random effect estimation for the linear model. Here the Breusch-Pagan statistic tests the null hypothesis that the variance of the random effect is zero. Rejecting this null hypothesis shows that both sources of variance exist. The estimation, however, leaves unchanged the pattern of results. Most importantly, the random effects estimation confirms a negative but insignificant coefficient on high pressure with threat of liquidation and the significant coefficient on high pressure without such a threat. The coefficient on the latter

continues to suggest that high competitive pressure without a threat of liquidation is associated with training nearly 1/5 more of the workforce.

A larger threat to this result may come from unmeasured factors that are correlated with both competitive pressure and training. Thus, unmeasured but constant (over the waves) product dimensions may make training a sensible managerial strategy and also make the market highly competitive. In this case, the estimated coefficient is biased upward and may largely reflect such unobserved time-invariant influences. To examine this we estimate a fixed effect specification that holds constant unobserved time-invariant influences by essentially measuring the consequences of change in competitive pressure within firms over time.

The second column of Table 3 shows the results of the linear fixed effects estimation. The variables for establishment age, multi-establishment firms, region and industry are excluded from the specification as they time-invariant or nearly time-invariant. A Hausman test rejects the hypothesis that the unique errors are uncorrelated with the regressors and indicates that the fixed effects model is preferred over a random effect model with the same specification.

Despite the importance of the fixed effects and the associated establishment heterogeneity, the pattern of key results remains robust. The consequence of an individual firm moving into a situation of intense competition without threat of liquidation is still significantly associated with an increase in training of about 1/5 of the workforce. The consequence of moving into a situation of intense competition with a threat of liquidation remains insignificant. Thus, even controlling for establishment level heterogeneity, the role of competition persists and continues to suggest an inverse U-shape in which the coefficients associated with greater competitive pressure grow, are statistically different from zero at high competition without threat of liquidation but shrink essentially to zero at high competition with threat of liquidation. By contrast, a series of the control

variables (i.e. the variables for works council incidence, collective bargaining coverage, foreign ownership, vacancies, establishment size, female employees and use of temporary agency work) become insignificant when taking fixed effects into account.[4]

Table 4 presents alternative random effects and fixed effects estimations. We return to Tobit which, again, recognizes that some establishments do no training and that the decision to train at all should be incorporated into the estimation. We recognize that the nonlinear Tobit suffers an incidental parameter problem in the fixed-effect specification. In general incidental parameters can be associated with bias in both coefficient and standard error estimation. We proceed and take solace from the Monte-Carlo experiments of Greene (2004a, 2004b) who demonstrates that the extent of the bias in estimates of both coefficients and disturbance variance is very small for panels with five or more waves. As our panel has seven years of observations (2009–2015), Greene's Monte-Carlo experiments increase confidence in our results.

The first column of Table 4 presents the Tobit with random effects and the second column presents the Tobit with fixed effects. The critical point is that the pattern from the linear estimates continues to carry over. While the fixed effect estimate again causes some control variables to lose statistical significance, the critical coefficient on high competitive pressure without threat of liquidation remains large and statistically significant. Thus, the pattern of results is robust both to controlling for fixed effects and to alternative functional forms. This strength would not be anticipated given past studies that were forced to use a measure that combined all cases of high competitive pressure.

4.3 Separate Estimates by Industry

Our use of the new self-reported measure of competitive pressure allows us to examine the full set of industries in the German economy. This ability to move beyond the manufacturing sample of Görlitz and Stiebale (2011) has likely helped generate the difference in results that we have presented. To explore this in more detail, we now divide our estimates by broad sector of the economy. We focus on manufacturing, service and other industries. As suggested by our background discussion, training may be a more natural way to compete in service industries where workers and their human capital are 'part of the product' (Batt 2008) than in manufacturing where firms may more naturally turn to cost saving technology.

Table 5 presents our core estimates for the linear models divided by the three broad sectors of the economy. We show both the random and fixed effect estimation.[5] The first panel shows the results for the service sector. They clearly confirm the inverted U-shape. The coefficients increase as does competitive pressure. The coefficient on high pressure without a threat of liquidation is slight larger than for the sample as a whole but again shows that roughly 1/5 more of the workforce will be trained. This result remains highly significant while that for high competitive pressure with a threat of liquidation is small or of varying sign and insignificantly different from zero.

The second panel presents the results for the manufacturing sector. Here none of the measures of competitive pressure are significantly different from zero. This can be seen as a confirmation of Görlitz and Stiebale (2011) who also found no role for competition in the manufacturing sector. In the random effects estimate the insignificance of the key coefficient results, in part, from a substantially smaller point estimate. In the fixed effects estimate, the insignificance results from an increase in the imprecision of the estimate.

In the other industries sector, the inverted U-shape in the coefficients broadly remains but may not be as dramatic. The coefficient for high pressure without threat of liquidation is large but only weakly significant in the random effect estimate. In the fixed effect estimate it returns to roughly the same size as comparable estimates in the other two sectors and loses statistical significance. It is important to note that in all three sectors the Hausman test continues to suggest that the fixed-effect estimate should be preferred.

To examine robustness we repeat this exercise of dividing the economy into three sectors but use the Tobit specification. This is presented in Table 6 and shows only a modestly different pattern. The service sector continues to give the strongest evidence of the inverted U-shape with statistical significance for high pressure with a threat of liquidation in both the random and the fixed effect estimation. Both the manufacturing sector and the other industries sector show significance in the random effects model that vanishes in the fixed effects model. Thus, while all sectors hint at the inverse U-shape, it receives strong support only in the service sector. This confirms the importance of being able to examine sectors beyond manufacturing.

5. Conclusion

This paper contributes new insights to the growing literature on whether or not product market competition stands as a determinant of employer provided training. While both past theory and evidence remain mixed, we have argued for a more nuanced view in two dimensions. First, competition should spur training investments only when that competition is not a threat to firm solvency. As the likelihood of insolvency increases, any expected returns on training diminish. Second, competition may be anticipated to increase training largely in those industries in which workers' human capital plays a more important role in the competitiveness of firms.

We take our evidence as suggesting the importance of these two points. Using recent German data that provides measures of competitive pressure for the entire economy, we show high competitive pressure is associated with training approximately 1/5 more of the workforce when that pressure does not threaten liquidation. Yet, when it does threaten liquidation, establishments with high pressure are no more likely to training than those establishments facing no competitive pressure. This result persists when accounting for establishment heterogeneity by holding constant time invariant establishment fixed effects and across several different estimation methods.

When focusing on manufacturing, we can recover earlier results suggesting the irrelevance of competition on training. Thus, our general finding is driven disproportionately by a strong and robust relationship in the service sector. This seem sensible as firms' competitiveness in these industries relies to a larger extent on workers' human capital. Thus, it is here where training may be a particularly effective competitive weapon.

These results suggest that future work using data from countries other than Germany should be careful to separate out those cases where competition threatens survival. This suggestion mirrors previous results on other investments such as R&D. Firms whose competitive position threatens their survival are unlikely to make long-term investments of any kind including training. Future work should also note the possibility of differences in the relationship between competition and training by broad sector. The role of training as a competitive strategy seems likely to differ by the role of the workers and should not be assumed to be homogenous.

References

Acemoglu, D. 1997. "Training and Innovation in an Imperfect Labor Market," *Review of Economic Studies* 64: 445-464.

Acemoglu, D. 2002. "Technical Change, Inequality and the Labor Market," *Journal of Economic Literature* 40: 7-72.

Acemoglu, D. and Pischke, J.S. 1998. "Why Do Firms Train? Theory and Evidence," *Quarterly Journal of Economics* 113: 79-119.

Acemoglu, D. and Pischke, J.S. 1999. "The Structure of Wages and Investment in General Training," *Journal of Political Economy* 107: 539-572.

Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P. 2005. "Competition and Innovation: an Inverted-U Relationship," *Quarterly Journal of Economics* 120: 701-728.

Aghion, P., Blundell, R., Griffith, R., Howitt, P. and Prantl, S. 2009. "The Effects of Entry on Incumbent Innovation and Productivity," *Review of Economics and Statistics* 91: 20-31.

Allaart, P., Bellmann, L. and Leber, U. 2009. "Company-Provided Further Training in Germany and the Netherlands," *Empirical Research in Vocational Education and Training* 1: 103-121.

Altonji, J.G. and Spletzer, J.R. 1991. "Worker Characteristics, Job Characteristics, and the Receipt of On-the-Job Training," *Industrial and Labor Relations Review* 45: 58-79.

Arulampalam, W., Booth, A.L. and Bryan, M.L. 2004. "Training in Europe," *Journal of the European Economic Association* 2: 346-360.

Askenazy, P., Cahn, C. and Irac, D. 2013. "Competition, R&D, and the Cost of Innovation: Evidence for France," *Oxford Economic Papers* 65: 293-311.

Autor, D.H. 2001. "Why Do Temporary Help Firms Provide Free General Skills Training?" *Quarterly Journal of Economics* 116: 1409-1448.

Autor, D.H., Levy, F. and Murane, R.J. 2003. "The Skill Content of Recent Technological Change," *Quarterly Journal of Economics* 118: 1297-1338.

Bassanini, A. and Brunello, G. 2011. "Barriers to Entry, Deregulation and Workplace Training," *European Economic Review* 55: 1152-1176.

Bassanini, A., Booth, A., Brunello, G., De Paola, M., and Leuven, E. 2007. "Workplace Training in Europe," in G. Brunello, P. Garibaldi, and E. Wasmer, eds., *Education and Training in Europe*, Oxford University Press, Oxford UK.

Batt, R. 2002. "Managing Customer Services: Human Resource Practices, Quit Rates, and Sales Growth," *Academy of Management Journal* 45: 587-597.

Batt, R. 2008. "Service Strategies Marketing, Operations, and Human Resource Practices," in P. Boxall, J. Purcell and P.M. Wright, eds., *The Oxford Handbook of Human Resource Management*, New York, Oxford University Press.

Becker, G. 1964. *Human Capital* (2nd edition), Columbia University Press.

Black, D.A, Noel, B.J. and Wang, Z. 1999. "On-the-Job Training, Establishment Size, and Firm Size: Evidence for Economies of Scale in the Production of Human Capital," *Southern Economic Journal* 66: 82-100.

Blanchflower, D. and Machin, S. 1996. "Product Market Competition, Wages and Productivity: International Evidence from Establishment Data," *Annals of Economics and Statistics/Annales D'Economie et de Statistique*, No. 41/42: 219-253.

Blechinger, D. and Pfeiffer, F. 2000. "Technological Change and Skill Obsolescence: The Case of German Apprenticeship Training," in J.A.M. Heijke and J. Muysken, eds., *Education, Training and Employment in the Knowledge Economy*, AEA-Macmillan Series, Houndsmill: 243-278.

Bloom, B., Sadun, R. and Van Reenen, J. 2010. "Does Product Market Competition Lead Firms to Decentralize?" *American Economic Review (Papers and Proceedings)* 100: 434-438.

Blundell, R., Dearden, L., Meghir, C. and Sianesi, B. 1999. "Human Capital Investment: The Returns from Education and Training to the Individual, the Firm and the Economy," *Fiscal Studies* 20: 1-23.

Boone, J. 2000. "Competitive Pressure: The Effects on Investments in Product and Process Innovation," *RAND Journal of Economics* 31: 549-569.

Booth, A. and Bryan, M. 2005. "Testing Some Predictions of Human Capital Theory: New Training Evidence from Britain," *Review of Economics and Statistics* 391-394.

Booth, A. and Snower, D. 1996. *Acquiring Skills: Market Failures, their Symptoms and Policy Responses*, Cambridge University Press.

Booth, A. and Zoega, G. 1999. "Do Quits Cause Under-Training?" *Oxford Economic Papers* 51: 374-386.

Bos, J.W.B., Kolari, J.W. and von Lamoen, R.C.R. 2013. "Competition and Innovation: Evidence from Financial Services," *Journal of Banking & Finance* 37: 1590-1601.

Bresnahan, T., Brynjolfsson, E. and Hitt, L.M. 2002. "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence," *Quarterly Journal of Economics* 117: 329-376.

Brunello, G. and Gambarotto, F. 2007. "Do Spatial Agglomeration and Local Labor Market Competition Affect Employer-Provided Training? Evidence from the UK," *Regional Science and Urban Economics* 37,' 1-21.

Brunello, G. and De Paola M. 2008. "Training and Economic Density: Some Evidence form Italian Provinces," *Labour Economics* 15: 118-140.

Brussig, M. and Leber, U. 2006. "Formal and Informal Ways of Learning in Employer-Provided Further Training in East and West German Enterprises: Results from a Large-Scale Establishment Survey," *Journal of East European Management Studies* 11: 305-325.

Carmichael, H.L. and MacLeod, W.B. 1993. "Multiskilling, Technical Change and the Japanese Firm," *Economic Journal* 103: 142-160.

Caroli, E. and Van Reenen, J. 2001. "Skill-Biased Organizational Change? Evidence from a Panel of British and French Establishments," *Quarterly Journal of Economics* 116: 1449-1492.

Dearden, L., Machin, S. Reed, F. and Wilkinson, D. 1997. *Labour Turnover and Work Related Training*. London: Institute for Fiscal Studies Report (R53). DOI:10.1920/re.ifs.1997.0053.

Dearden, L., Reed, H. and Van Reenen, J. 2006. "The Impact of Training on Productivity and Wages: Evidence from British Panel Data," *Oxford Bulletin of Economics and Statistics* 68: 397-421.

Ding, S., Sun, P., and Wei, J. 2016. "The Effect of Import Competition on Firm Productivity and Innovation: Does the Distance to Technology Frontier Matter?" *Oxford Bulletin of Economics and Statistics* 78: 197-227.

Freeman, R.B. and Lazear, E.P. 1995. "An Economic Analysis of Works Councils," in J. Rogers and W. Streeck, eds., *Works Councils – Consultation, Representation and Cooperation in Industrial Relations*, Chicago: University of Chicago Press: 27 – 52.

Fischer, G., Janik, F., Mueller, D., and Schmucker, A. 2009. "The IAB Establishment Panel – Things Users Should Know," *Journal of Applied Social Science Studies* 129: 133-148.

Fisman, R. and Svensson, J. 2007. "Are Corruption and Taxation Really Harmful to Growth? Firm Level Evidence," *Journal of Development Economics* 83: 63-75.

Gashi, A.N., G. Pugh and Adnett, N. 2008. "Technological Change and Employer Provided Training: Evidence from German Establishments," Leading House Working Paper No. 26, Zurich.

Gashi, A.N., G. Pugh and Adnett, N. 2010. "Technological Change and Employer-Provided Training: Evidence from UK Workplaces," *International Journal of Manpower* 31: 426-448.

Gerlach, K. and Jirjahn, U. 2001. "Employer Provided Further Training: Evidence from German Establishment Data," *Journal of Applied Social Science Studies* 121: 1-26.

Gersbach, H and Schmutzler, A. 2012. "Product Market and Industry-Specific Training," *RAND Journal of Economics* 43: 475-491.

Görlitz, K. and Stiebale, J. 2011. "The Impact of Product Market Competition on Employers' Training Investments. Evidence from German Establishment Panel Data," *De Economist* 159: 1-23.

Greene, W. 2004a. The Behaviour of the Maximum Likelihood Estimator of Limited Dependent Variable Models in the Presence of Fixed effects. *Econometrics Journal* 7(1): 98.

Greene, W. 2004b. Fixed Effects and Bias Due to the Incidental Parameters Problem in the Tobit Model. *Econometric Reviews* 23(2): 125-147.

Hardes, H.D. 1991. "Tarifverträge zur betrieblichen Weiterbildung – Darstellung und Analyse aus arbeitsökonomischer Sicht," *Mitteilungen aus der Arbeitsmarkt- und Berufsforschung* 24: 658-672.

Harhoff, D. and Kane, T.J. 1997. "Is the German Apprenticeship System a Panacea for the U.S. Labor Market?" *Journal of Population Economics* 10: 171-196.

Hipp, C. and H. Grupp. 2005. "Innovation in the Service Sector: The Demand for Service-Specific Innovation Measurement Concepts and Typologies," *Research Policy* 34: 517-535.

Jirjahn, U. and Kraft, K. 2010. "Teamwork and Intra-Firm Wage Dispersion among Blue-Collar Workers," *Scottish Journal of Political Economy* 57: 404-429.

Jirjahn, U., Mohrenweiser, J. and Backes-Gellner, U. 2011. "Works Councils and Learning: On the Dynamic Dimension of Codetermination," *Kyklos* 64: 427-447.

Jirjahn, U. and Mueller, S. 2014. "Nonunion Worker Representation, Foreign Owners and Firm Performance," *Oxford Economic Papers* 66: 140-163.

Jirjahn, U. and S.C. Smith. 2006. "What Factors Lead Management to Support or Oppose Employee Participation – With and Without Works Councils? Hypotheses and Evidence from Germany," *Industrial Relations* 45: 650-680.

Jones, D.C., Kalmi, P. and Kauhanen, A. 2012. "The Effects of General and Firm-Specific Training on Wages and Performance: Evidence from Banking," *Oxford Economic Papers* 151: 151-175.

Katz, E. and Ziderman, A. 1990. "Investment in General Training: The Role of Information and Labour Mobility," *Economic Journal* 100: 1147-1158.

Kilponen, J. and Santavirta, T. 2007. "When Do R&D Subsidies Boost Innovation? Revisiting the Inverted U-Shape," Bank of Finland Discussion Paper No. 10/2007.

Konings, J. and Vanormelingen, S. 2015. "The Impact of Training on Productivity and Wages: Firm-Level Evidence," *Review of Economics and Statistics* 97: 485-497.

Krueger, A. B. 1993. "How Computers Have Changed the Wage Structure: Evidence from Micro Data, 1984-1989," *Quarterly Journal of Economics* 108, 33-60.

Lai, Tat-Kei. and Ng, T. 2014. "The Impact of Product Market Competition on Training Provision: Evidence from Canada," *Canadian Journal of Economics* 47: 856-888.

Lazear, E.P. 2009. "Firm-Specific Human Capital: A Skill-Weights Approach," *Journal of Political Economy* 117: 914-940.

Levin, R.C., Cohen, W.M. and Mowery, D.C. 1985. "R&D Appropriability, Opportunity, and Market Structure: New Evidence on Some Schumpeterian Hypotheses," *American Economic Review (Papers and Proceedings)* 75: 20-24.

Li, H.C. 2009. "Import Competition and Company Training," Working Paper, University of South Carolina.

Lynch, L.M. 1994. *Training and the Private Sector: International Comparisons*. The University of Chicago Press. Chicago and London. Edited by Lisa M. Lynch (NBER comparative labor market series).

Lynch, L.M. and Black, S.E. 1998. "Beyond the Incidence of Employer-Provided Training," *Industrial and Labor Relations Review* 52: 64-81.

Manning, A. 2003. *Monopsony in Motion: Imperfect Competition in Labor Markets*, Princeton University Press, Princeton and Oxford.

Moretti, E. 2004. "Workers' Education, Spillovers and Productivity: Evidence from Plant Level Production Functions," *American Economic Review* 94: 656-690.

Muehlemann, S. and Wolter, S.C. 2007. "Regional Effects on Employer-Provided Training: Evidence from Apprenticeship Training in Switzerland," *Journal for Labour Market Research* 40: 135-147.

Munasinghe, L. and O'Flaherty, B. 2005. "Specific Training Sometimes Cuts Wages and Always Cuts Turnover," *Journal of Labor Economics* 23: 213-233.

Papke, L. E. and Wooldridge, J. M. 1996. "Econometric Methods for Fractional Response Variables with an Application to 401(k) Plan Participation Rates," *Journal of Applied Econometrics* 11: 619–632.

Peneder, M. and Woerter, M. 2014. "Competition, R&D and Innovation: Testing the Inverted-U in a Simultaneous System," *Journal of Evolutionary Economics* 24: 653-687.

Picchio, M. and Van Ours, J. 2011. "Market Imperfections and Firm-Sponsored Training," *Labour Economics* 18: 712-722.

Polder, M. and Veldhuizen, E. 2014. "Innovation and Competition in the Netherlands: Testing the Inverted-U for Industries and Firms," *Journal of Industry, Competition and Trade* 12: 67-91.

Seyda, S. and Werner, D. 2014. "IW-Weiterbildungserhebung 2014 – Höheres Engagement und mehr Investitionen in betriebliche Weiterbildung," IW-Trends 4/2014, Köln.

Skaggs, B.C. and Youndt, M. 2004. "Strategic Positioning, Human Capital, and Performance in Service Organizations: A Customer Interaction Approach," *Strategic Management Journal* 25: 85-99.

Smith, S.C. 2006. "Employee Participation Rights in Corporate Governance: Economic Rationale, a Test of a Leading Theory, and Some Modest Policy Proposals," *Advances in the Economic Analysis of Participatory and Labor Managed Firms* 9: 105-146.

Stevens, M. 1994. "A Theoretical Model of on-the-Job Training with Imperfect Competition," *Oxford Economic Papers* 46: 537-562.

Tingvall, P.G. and Karpaty, P. 2011. "Service-Sector Competition, Innovation and R&D," *Economics of Innovation and New Technology* 20: 63-88.

Tingvall, P.G. and Poldahl, A. 2006. "Is There Really an Inverted U-Shaped Relationship between Competition and R&D?" *Economics of Innovation and New Technology* 15: 101-118.

Vives, X. 2008. "Innovation and Competitive Pressure," *Journal of Industrial Economics* 56: 419-469.

Whitfield, K. 2000. "High-Performance Workplaces, Training, and the Distribution of Skills," *Industrial Relations* 39: 1-25.

Winkelmann, R. 1996. "Employment Prospects and Skill Acquisition of Apprenticeship-Trained Workers in Germany." *Industrial and Labor Relations Review* 49: 658-672.

Wolter, S.C. and Ryan, P. 2011. “Apprenticeship,” in Hanushek, E.A., Machin S. and Woessmann, L., eds., *Handbook of Economics of Education*, Vol. 3, Elsevier: 521-576.

Xu, K. and Lin, Z. 2011. “Participation in Workplace Employer-Sponsored Training in Canada: Role of Firm Characteristics and Worker Attributes,” *Contemporary Economic Policy* 29: 416-430.

Zwick, T. 2006. “The Impact of Training Intensity on Establishment Productivity,” *Industrial Relations* 45: 26-46.

Tables

Table 1: Variable Definitions and Descriptive Statistics

Variable	*Definition (Mean, Standard Deviation)*
Training intensity	Share of the establishment's employees receiving further training in the first half of the year (0.28, 0.33).
High competitive pressure with threat of liquidation	Dummy equals 1 if the establishment reports high competitive pressure entailing a threat of liquidation (0.15, 0.35).
High competitive pressure without threat of liquidation	Dummy equals 1 if the establishment reports high competitive pressure, but faces no threat of liquidation (0.29, 0.46).
High competitive pressure (either type)	Dummy equals 1 if the establishment reports high competitive pressure with or without threat of liquidation (0.44, 0.50).
Medium competitive pressure	Dummy equals 1 if the establishment reports medium competitive pressure (0.40, 0.49).
Minor competitive pressure	Dummy equals 1 if the establishment reports minor competitive pressure (0.12, 0.32).
Multi-establishment firm	Dummy equals 1 if the establishment is part of a multi-establishment firm (0.23, 0.42).
Foreign ownership	Dummy equals 1 if the establishment has a dominant foreign owner (0.07, 0.25).
Dispersed ownership	Dummy equals 1 if no single owner holds majority (0.03, 0.17).
Founded after 1990	Dummy equals 1 if the establishment was founded after the year 1990 (0.61, 0.49).
Establishment size	Number of employees at the establishment (83.41, 600.16).
Establishment size squared	Number of employees squared.
Investment per capita	Amount of investments in physical capital (in Euro) divided by the number of employees (4821.151, 37992.19)
Investment in information technology	Dummy equals 1 if the establishment invested in computer systems or in information and communication technology (0.41, 0.49).
Investment in machines	Dummy equals 1 if the establishment invested in production facilities, plant and equipment, or furniture and fixtures (0.47, 0.50).
Vintage of technology	Ordered variable for the vintage of production technology where 1 = very old, . . ., 5 = state of the art (3.81, 0.78).
Collective bargaining	Dummy equals 1 if the establishment is covered by a collective bargaining agreement (0.38, 0.49).
Works council	Dummy equals 1 if a works council is present in the establishment (0.21, 0.40).
Employee Involvement	Dummy equals 1 if the establishment uses alternative forms of employee involvement such as staff spokesmen, round tables or worker committees (0.11, 0.31)
Temporary agency workers	Dummy equals 1 if the establishment uses temporary agency workers (0.16, 0.37).
Part-time employees	Part-time employees as a share of the establishment's workforce (0.24, 0.26).

Women	Female employees as a share of the establishment's workforce (0.40, 0.30).
Apprentices	Apprentices as a share of the establishment's workforce (0.04, 0.08).
Skilled workers	Employees with completed apprenticeship training as a share of the establishment's workforce (0.61, 0.27).
University graduates	University graduates as a share of the establishment's workforce (0.07, 0.15).
Vacancies for unskilled workers	Dummy equals 1 if the establishment has job vacancies for unskilled workers (0.06, 0.24).
Vacancies for skilled and high-skilled workers	Dummy equals 1 if the establishment has job vacancies for skilled workers and university graduates (0.27, 0.45).
Difficulties in filling vacancies	Dummy equals 1 if the establishment has difficulties in filling job vacancies for skilled and workers and university graduates (0.16, 0.37)
Industry dummies	15 industry dummies are included.
Region dummies	Dummies for Northern West Germany, Southern West Germany and Western West Germany are included.
Time dummies	Dummies for the years 2010 to 2015 are included.

Number of observations = 51,676. The reference groups for the mutually exclusive dummy variables are as follows: Establishments with no competitive pressure (with a dominant domestic owner, with location in East Germany, in the year 2009) form the reference group for the competition dummies (ownership dummies, region dummies, time dummies).

Table 2: Pooled Estimations

Variable	*OLS*	*OLS*	*Tobit*	*Fractional Probit*
High competitive pressure with threat of liquidation	---	-0.008 (0.0071)	-0.004 [-0.002] (0.0117)	-0.025 [-0.008] (0.0243)
High competitive pressure without threat of liquidation	---	0.018 (0.0067)**	0.047 [0.027] (0.0109)***	0.061 [0.019] (0.0226)**
High competitive pressure (either type)	0.009 (0.0065)	---	---	---
Medium competitive pressure	0.007 (0.0065)	0.007 (0.0065)	0.024 [0.014] (0.0107)**	0.027 [0.008] (0.0220)
Minor competitive pressure	0.001 (0.0072)	0.001 (0.0072)	0.011 [0.006] (0.0118)	0.005 [0.002] (0.0243)
Multi-establishment firm	0.049 (0.0036)***	0.048 (0.0036)***	0.084 [0.049] (0.0056)***	0.145 [0.045] (0.0112)***
Foreign ownership	0.023 (0.0056)***	0.024 (0.0056)***	0.029 [0.016] (0.0089)***	0.074 [0.022] (0.0182)***
Dispersed ownership	-0.007 (0.0079)	-0.007 (0.0079)	-0.016 [-0.008] (0.0125)	-0.029 [-0.008] (0.0245)
Founded after 1990	0.012 (0.0030)***	0.012 (0.0030)***	0.021 [0.012] (0.0048)***	0.044 [0.013] (0.0097)***
Establishment size	$-4x10^{-5}$ $(6x10^{-6})$***	$-4x10^{-5}$ $(6x10^{-6})$***	$-5x10^{-5}$ $[-3x10^{-5}]$ $(9x10^{-6})$***	$-1x10^{-4}$ $[-4x10^{-5}]$ $(3x10^{-5})$***
Establishment size squared	$8x10^{-10}$ $(1x10^{-10})$***	$8x10^{-10}$ $(1x10^{-10})$***	$9x10^{-10}$ $[5x10^{-10}]$ $(2x10^{-10})$***	$2x10^{-9}$ $[7x10^{-10}]$ $(5x10^{-10})$***
Investment per capita	$5x10^{-8}$ $(4x10^{-8})$	$5x10^{-8}$ $(4x10^{-8})$	$4x10^{-8}$ $[2x10^{-8}]$ $(6x10^{-8})$	$1x10^{-7}$ $[4x10^{-8}]$ $(2x10^{-7})$
Investment in information technology	0.048 (0.0030)***	0.047 (0.0030)***	0.090 [0.050] (0.0048)***	0.150 [0.045] (0.0097)***
Investment in machines	0.023 (0.0030)***	0.022 (0.0030)***	0.058 [0.032] (0.0048)***	0.078 [0.023] (0.0097)***
Vintage of technology	0.044 (0.0018)***	0.043 (0.0018)***	0.074 [0.043] (0.0029)***	0.142 [0.044] (0.0059)***
Collective bargaining	0.021 (0.0030)***	0.021 (0.0030)***	0.039 [0.021] (0.0049)***	0.070 [0.020] (0.0098)***
Works council	0.024 (0.0041)***	0.023 (0.0041)***	0.070 [0.038] (0.0063)***	0.071 [0.021] (0.0129)***
Employee involvement	0.059 (0.0043)***	0.059 (0.0043)***	0.101 [0.056] (0.0068)***	0.176 [0.053] (0.0134)***
Temporary agency workers	0.019 (0.0041)***	0.018 (0.0041)***	0.054 [0.029] (0.0064)***	0.069 [0.020] (0.0130)***
Part-time employees	-0.027 (0.0069)***	-0.026 (0.0069)***	-0.090 [-0.052] (0.0114)***	-0.108 [-0.033] (0.0238)***
Women	0.090 (0.0062)***	0.090 (0.0062)***	0.142 [0.082] (0.0102)***	0.298 [0.092] (0.0210)***

Apprentices	0.223 (0.0181)***	0.222 (0.0181)***	0.488 [0.284] (0.0290)***	0.777 [0.239] (0.0605)***
Skilled workers	0.152 (0.0060)***	0.150 (0.0060)***	0.297 [0.173] (0.0100)***	0.551 [0.170] (0.0214)***
University graduates	0.289 (0.0104)***	0.288 (0.0104)***	0.493 [0.287] (0.0165)***	0.915 [0.282] (0.0336)***
Vacancies for unskilled workers	-0.026 (0.0059)***	-0.027 (0.0059)***	0.001 [0.001] (0.0095)	-0.067 [-0.020] (0.0204)***
Vacancies for skilled and high-skilled workers	0.013 (0.0036)***	0.013 (0.0036)***	0.032 [0.018] (0.0057)***	0.039 [0.012] (0.0116)***
Difficulties in filling vacancies	0.015 (0.0043)***	0.015 (0.0043)***	0.027 [0.015] (0.0067)***	0.045 [0.014] (0.0134)***
Constant	-0.201 (0.0144)***	-0.193 (0.014)***	-0.673 (0.0239)***	-2.215 (0.0483)***
Industries dummies	Included	Included	Included	Included
Region dummies	Included	Included	Included	Included
Time dummies	Included	Included	Included	Included
R^2	0.175	0.175	---	---
Log likelihood	---	---	-35322.534	-28169.436
Number of observations	51,676	51,676	51,676	51,676
Number of establishments	17,115	17,115	17,115	17,115

Dependent variable: Training intensity. The table shows the estimated coefficients. Standard errors are in parentheses. Average marginal effects are in square brackets. Marginal effects of dummy variables are evaluated for a discrete change from 0 to 1. Marginal effects of the dummies for competitive pressure (ownership, region) are changes in probability compared to the reference group of establishments with no competitive pressure (establishments with a dominant domestic owner, establishments with location in East Germany). *Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Table 3: Random Effects and Fixed Effects Estimations

Variable	*Random Effects*	*Fixed Effects*
High competitive pressure with threat of liquidation	-0.003 (0.0070)	0.005 (0.0087)
High competitive pressure without threat of liquidation	0.018 (0.0066)**	0.019 (0.0082)**
Medium competitive pressure	0.008 (0.0063)	0.011 (0.0077)
Minor competitive pressure	0.005 (0.0067)	0.010 (0.0079)
Multi-establishment firm	0.036 (0.0042)***	---
Foreign ownership	0.019 (0.0069)**	0.005 (0.0123)
Dispersed ownership	0.001 (0.0082)	0.013 (0.0111)
Founded after 1990	0.007 (0.0039)*	---
Establishment size	$-2x10^{-5}$ ($7x10^{-6}$)**	$4x10^{-6}$ (0.0001)
Establishment size squared	$4x10^{-10}$ ($1x10^{-10}$)**	$-3x10^{-10}$ ($7x10^{-10}$)
Investment per capita	$1x10^{-8}$ ($3x10^{-8}$)	$7x10^{-8}$ ($10x10^{-8}$)
Investment in information technology	0.029 (0.0028)***	0.013 (0.0033)***
Investment in machines	0.017 (0.0028)***	0.011 (0.0032)***
Vintage of technology	0.028 (0.0018)***	0.011 (0.0023)***
Collective bargaining	0.015 (0.0036)***	0.003 (0.0054)
Works council	0.029 (0.0052)***	0.001 (0.0114)
Employee involvement	0.041 (0.0043)***	0.020 (0.0053)***
Temporary agency workers	0.010 (0.0042)**	-0.004 (0.0053)
Part-time employees	-0.035 (0.0078)***	-0.024 (0.0116)**
Women	0.080 (0.0080)***	0.021 (0.0173)
Apprentices	0.189 (0.0212)***	0.058 (0.0327)*
Skilled workers	0.130 (0.0066)***	0.051 (0.0098)***
University graduates	0.256 (0.0126)***	0.078 (0.0227)***
Vacancies for unskilled workers	-0.010 (0.0054)*	0.004 (0.0064)
Vacancies for skilled and high-skilled workers	0.011 (0.0032)***	0.006 (0.0036)
Difficulties in filling vacancies	0.012 (0.0038)**	0.008 (0.0043)*
Constant	-0.110 (0.0184)***	0.125 (0.0165)***
Industries dummies	Included	Not included
Region dummies	Included	Not included
Time dummies	Included	Included
R^2	0.1721	0.0743
Breusch Pagan test (χ^2)	18653.77***	---
Hausman test (χ^2)	---	826.11***
Number of observations	51,676	51,676
Number of establishments	17,115	17,115

Dependent variable: Training intensity. The table shows the estimated coefficients. Standard errors are in parentheses. *Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Table 4: Random Effects and Fixed Effects Tobit Estimations

Variable	*Random Effects Tobit*	*Fixed Effects Tobit*
High competitive pressure with threat of liquidation	0.001 [0.001] (0.0116)	-0.008 (0.0168)
High competitive pressure without threat of liquidation	0.041 [0.024] (0.0108)***	0.031 (0.0157)**
Medium competitive pressure	0.023 [0.013] (0.0104)**	0.020 (0.0150)
Minor competitive pressure	0.015 [0.009] (0.0111)	0.015 (0.0150)
Multi-establishment firm	0.066 [0.039] (0.0067)***	---
Foreign ownership	0.024 [0.013] (0.0109)**	-0.009 (0.0202)
Dispersed ownership	-0.007 [-0.004] (0.0131)	0.016 (0.0180)
Founded after 1990	0.011 [0.006] (0.0063)*	---
Establishment size	$-1x10^{-5}$ [$-6x10^{-6}$] (0.0001)	$9x10^{-6}$ (0.0001)
Establishment size squared	$2x10^{-10}$ [$1x10^{-10}$] ($2x10^{-10}$)	$-3x10^{-10}$ ($5x10^{-10}$)
Investment per capita	$-5x10^{-9}$ [$-3x10^{-9}$] ($6x10^{-8}$)	$-9x10^{-8}$ ($1x10^{-7}$)
Investment in information technology	0.053 [0.030] (0.0044)***	0.017 (0.0047)***
Investment in machines	0.042 [0.023] (0.0044)***	0.016 (0.0050)***
Vintage of technology	0.049 [0.028] (0.0030)***	0.017 (0.0041)***
Collective bargaining	0.032 [0.018] (0.0057)***	-0.002 (0.0089)
Works council	0.082 [0.047] (0.0081)***	-0.001 (0.0164)
Employee involvement	0.072 [0.041] (0.0067)***	0.026 (0.0080)***
Temporary agency workers	0.029 [0.016] (0.0065)***	-0.006 (0.0073)
Part-time employees	-0.102 [-0.059] (0.0129)***	-0.049 (0.0224)**
Women	0.117 [0.068] (0.0131)***	0.037 (0.0330)
Apprentices	0.414 [0.241] (0.0342)***	0.062 (0.0554)

Skilled workers	0.261 [0.152] (0.0112)***	0.107 (0.0219)***
University graduates	0.446 [0.260] (0.0200)***	0.140 (0.0391)***
Vacancies for unskilled workers	0.008 [0.005] (0.0087)	0.007 (0.0102)
Vacancies for skilled and high-skilled workers	0.026 [0.015] (0.0050)***	0.007 (0.0051)
Difficulties in filling vacancies	0.022 [0.013] (0.0059)***	0.013 (0.0059)**
Constant	-0.528 (0.0307)***	---
Industries dummies	Included	Not included
Region dummies	Included	Not included
Time dummies	Included	Included
Rho	0.4950 (0.0055)***	---
Log likelihood	-30123.393	---
Number of observations	51,676	51,676
Number of establishments	17,115	17,115

Dependent variable: Training intensity. The table shows the estimated coefficients. Standard errors are in parentheses. Average marginal effects are in square brackets. Marginal effects of dummy variables are evaluated for a discrete change from 0 to 1. Marginal effects of the dummies for competitive pressure (ownership, region) are changes in probability compared to the reference group of establishments with no competitive pressure (establishments with a dominant domestic owner, establishments with location in East Germany). Note that marginal effects are not available for the fixed effects tobit. Rho is the cross-period correlation of errors terms in the random effects models. *Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Table 5: Separate Random and Fixed Effects Estimations by Industry

	Service Sector		Manufacturing Sector		Other Sectors	
Variable	*Random Effects*	*Fixed Effects*	*Random Effects*	*Fixed Effects*	*Random Effects*	*Fixed Effects*
High competitive pressure with threat of liquidation	-0.008 (0.0092)	0.003 (0.0116)	-0.002 (0.0142)	0.010 (0.0172)	0.017 (0.0197)	0.007 (0.0241)
High competitive pressure without threat of liquidation	0.020 (0.0084)**	0.021 (0.0106)**	0.013 (0.0138)	0.020 (0.0165)	0.035 (0.0187)*	0.021 (0.0226)
Medium competitive pressure	0.011 (0.0080)	0.011 (0.0099)	0.001 (0.0134)	0.010 (0.0160)	0.022 (0.0180)	0.022 (0.0216)
Minor competitive pressure	0.006 (0.0085)	0.010 (0.0101)	-0.003 (0.0140)	0.009 (0.0162)	0.017 (0.0192)	0.016 (0.0220)
R^2	0.1925	0.0668	0.1198	0.0291	0.1046	0.0158
Breusch Pagan test (χ^2)	10129.71***	---	4753.57***	---	1818.51***	---
Hausman test (χ^2)	---	566.11***	---	168.98***	---	93.05***
Number of observations	28,349	28,349	16,819	16,819	6,508	6,508
Number of establishment	9,947	9,947	5,196	5,196	1,972	1,972

Dependent variable: Training intensity. The table shows the estimated coefficients. Standard errors are in parentheses. *Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level. Results on the control variables are suppressed to save space.

Table 6: Separate Random and Fixed Effects Tobit Estimations by Industry

	Service Sector		Manufacturing Sector		Other Sectors	
Variable	*Random Effects Tobit*	*Fixed Effects Tobit*	*Random Effects Tobit*	*Fixed Effects Tobit*	*Random Effects Tobit*	*Fixed Effects Tobit*
High competitive pressure with threat of liquidation	-0.018 [-0.010] (0.0151)	-0.003 (0.0203)	0.027 [0.015] (0.0234)	0.024 (0.0450)	0.027 [0.014] (0.0355)	0.008 (0.0507)
High competitive pressure without threat of liquidation	0.037 [0.022] (0.0138)**	0.031 (0.0184)*	0.049 [0.028] (0.0227)**	0.037 (0.0436)	0.067 [0.035] (0.0335)*	0.037 (0.0484)
Medium competitive pressure	0.022 [0.013] (0.0131)*	0.018 (0.0172)	0.031 [0.018] (0.0222)	0.025 (0.0430)	0.042 [0.022] (0.0324)	0.038 (0.0473)
Minor competitive pressure	0.013 [0.008] (0.0140)	0.013 (0.0174)	0.021 [0.012] (0.0233)	0.019 (0.0430)	0.030 [0.015] (0.0343)	0.028 (0.0456)
Rho	0.4985 (0.0075)***	---	0.4572 (0.010)***	---	0.4894 (0.0163)***	---
Log likelihood	-17805.185	---	-8136.217	---	-3842.9297	---
Number of observations	28,349	28,349	16,819	16,819	6,508	6,508
Number of establishment	9,947	9,947	5,196	5,196	1,972	1,972

Dependent variable: Training intensity. The table shows the estimated coefficients. Standard errors are in parentheses. Average marginal effects are in square brackets. Marginal effects of dummy variables are evaluated for a discrete change from 0 to 1. Marginal effects of the dummies for competitive pressure are changes in probability compared to the reference group of establishments with no competitive pressure. Note that marginal effects are not available for the fixed effects tobit. Rho is the cross-period correlation of errors terms in the random effects models. *Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level. Results on the control variables are suppressed to save space.

Endnotes

[1] See Boone (2000) for a similar distinction.

[2] Aggregated industrial codes often combine detailed industries with very different market structures. A self-reported firm-specific measure of product market competition does not involve the problem of assigning firms to specific industries based on aggregated industrial codes.

[3] As a consequence it also widens the wage gap between skilled and less skilled workers (Jirjahn and Kraft 2010).

[4] Jirjahn and Mueller (2014) discuss several reasons why the fixed effects approach may fail to reveal the true influence of works councils. First, long-term learning processes play an important role in the functioning of works councils (Jirjahn et al. 2011), but the fixed effects model relies only on establishments with changes in the works council status. This implies that only newly implemented works councils with rather weak effects are considered. Second, very few establishments change their works council status implying small within variation.

[5] Analogous pooled estimates (that ignore the panel structure) show similar results and are available upon request.